THE SURGICAL ANATOMY

OF THE

OPERATION OF SUPRAPUBIC PROSTATECTOMY.

BY

J. W. THOMSON WALKER, M.B., F.R.C.S.

Reprinted from "ARCHIVES OF THE MIDDLESEX HOSPITAL," VOL. IV., 1905.

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Introduction.

As Mr. Pearce Gould has reminded us, the anatomist must frequently follow in the footsteps of the surgeon, and it is not unusual that the finer points in regard to the relations of an organ are only clearly grasped in the endeavour to follow the track of the operator.

The operation of prostatectomy has been so prominently brought before the profession in the last few years that interest in the anatomy of the prostate has been aroused. The subject appeared to me to be ripe for revision, the more so that considerable divergence existed between the views of various writers, and further, there were many apparent gaps between the description in the anatomical text-books and the anatomical lines along which the operation of prostatectomy was being carried.

I therefore commenced an investigation in order to explain some apparent discrepancies between the surgery and the anatomy of the prostate, and approached the subject rather from the surgical than from the purely anatomical standpoint.

At the outset it was evident that the descriptions in our anatomical text-books were an insufficient basis on which to work, for not only did the accounts of the anatomy of the prostate and its surroundings vary in different descriptions, but many points which were vital to the subject were passed by unnoticed.

It was therefore necessary to lay aside all preconceived ideas of the surgical anatomy of the gland and to dissect and cut sections of the prostate and its surroundings for my own instruction. The scope of the investigation was thus indefinitely

widened. I endeavoured, however, to treat only such points as were important surgically. Although it has been necessary for the sake of continuity to fill in the gaps with well-recognized anatomical truths, I have tried to avoid confusing the issue by turning aside to anatomical points, however interesting, which have no direct bearing on the operation of suprapubic prostatectomy.

The work was carried out in the Physiological Laboratory of The Middlesex Hospital Medical School, and I must express my gratitude to Dr. Young and Dr. Goodall for the facilities they gave me during the somewhat protracted period of investigation. I was further, through Dr. Young's kindness, enabled to obtain excellent material in the post-mortem room of the Hospital. Additional material was supplied to me by Dr. Lunn of the Marylebone Infirmary.

It was early apparent that certain changes took place in the relation of the enlarged prostate to its surroundings which facilitated the surgical removal of the gland, for attempts to remove the normal gland by post-mortem operations were unsuccessful. It was therefore important to investigate these changes.

For the study of the parts removed at the operation Mr. P. J. Freyer kindly put at my disposal 73 specimens of enucleated prostates. I was convinced, however, that the study of even a large number of such specimens alone was open to fallacy in an endeavour to define the limits of the operation. In the operation of prostatectomy, which is very rapidly carried out by manipulations with the finger, shreds of tissue must not infrequently be torn from the surface of the specimen during removal, either from the prostatic cavity or from the cavity of the bladder. I have myself, in searching the bladder after a prostatectomy, discovered shreds of prostatic capsule lying loose in the cavity, and it was apparent that, had I examined this specimen and judged all prostatectomies therefrom, my conclusions must have been fallacious. It therefore became necessary to obtain specimens of the parts left behind after the operation of prostatectomy. I endeavoured at first to investigate this part of the subject by operations upon enlarged prostates in the dead body, but I was disappointed in the result; for, although in one case I was able to remove the prostate

entire and could find no trace of prostatic tissue on dissecting the parts left behind, yet in the next I merely shelled out some rounded adenomata. I now know from more extended observation and from the experience of others that both these procedures may find their counterpart in the living body,* but it is only to the more complete operation that this investigation applies.

Later I was able to collect four post-mortem specimens from cases in which prostatectomy was performed. With this material I have endeavoured to come to some conclusions in regard to the surgical anatomy of the operation of suprapubic prostatectomy.†

The subject is divided into the following five parts :—

1. Some points in the anatomy of the prostate and its surroundings in relation to prostatectomy ;
2. Changes in the prostate and its surroundings in enlargement of the organ ;
3. The structures removed in prostatectomy ;
4. The parts left behind after prostatectomy ;
5. Observations upon the operation of prostatectomy.

I.—SOME POINTS IN THE NORMAL ANATOMY OF THE PROSTATE AND ITS SURROUNDINGS.

If the bladder and prostate, together with the rectum and levatores ani muscles, be removed from the body, the following points may be observed :—

The Sheath.

A covering is provided for the prostate by the recto-vesical layer of pelvic fascia, and this Sir Henry Thompson called the "sheath." Although this nomenclature has not been widely adopted by anatomical writers, I have used it here as it distinguishes this layer of fascia clearly from the tissue immediately surrounding the prostatic gland tubules, which Thompson called the capsule. The importance of the definition of these terms will become more apparent when the line of cleavage of the

* Attention has been drawn by Mr. Pearce Gould ("Lancet," March 26th, 1904), Mr. Swinford Edwards (*idem*), and Mr. Southam ("British Medical Journal," April 18th, 1903), to these "intracapsular prostatectomies."

† The result of this investigation was recorded in a paper presented at the Royal Medical and Chirurgical Society on March 22nd, 1904.

operation comes to be discussed. The recto-vesical fascia passes inwards from the side wall of the pelvis on the upper surface of the levator ani muscle. It meets the lateral aspect of the junction of the prostate and bladder and becomes attached there. A strong layer of this fascia passes downwards, covering the side of the prostate.

If horizontal sections of the prostate and its surroundings be examined it will be seen that a process of this covering fascia splits off and joins that of the other side, covering in the posterior surface of the prostate and separating it from the rectum. If this posterior layer be followed upwards it is found to envelop the seminal vesicles.

On tracing a lateral layer forwards it is found to pass almost to the middle line in front of the prostate, and then turn forwards away from the prostate. The lines along which these two lateral layers pass off from the front of the prostate leave a comparatively broad space of the anterior surface of the gland uncovered at its base. As the prostate narrows towards its apex, the line of reflexion which is vertical passes gradually off the gland, so that the apex and about a quarter of the gland does not come into relation with these lateral layers.

The front of the gland at its base is covered by a thick layer of fascia between these lateral layers, and this, as the prostate narrows towards its apex, enwraps more and more of the circumference, uniting eventually with the fascia covering the posterior surface of the organ.

In sections of the prostate and its surroundings, at the level of the verumontanum, at right angles to the urethra, the recto-vesical layer of pelvic fascia is seen (Fig. 1, c), and the splitting off of the layer which passes between the prostate and the rectum recognized. In the angle formed by this division of fasciæ some fair-sized blood-vessels are usually found. These vessels belong to the prostate proper, and are quite separate from the prostatic plexus. One or more small lymph-glands may frequently be seen lying in close relation to the recto-vesical layer of fascia as it approaches the prostate.*

* These small lymph-glands are of clinical importance. They may sometimes be found on rectal examination as hard pea-sized nodules lying on either side of the prostate, and may give valuable information in regard to the malignancy of a diseased prostate.

The splitting of these layers is not always so definite as that just described. The recto-vesical layer sometimes gives off several layers of fascia which, however, eventually unite to form the posterior layer of the sheath.

The pelvic fascia thus provides a complete sheath for the prostate which envelops it, except at its basal attachment to the bladder and at its extreme apex. Outside this sheath lie

FIG. 1.—HORIZONTAL SECTION OF NORMAL PROSTATE AT LEVEL OF VERUMONTANUM.

A. Wall of rectum. B. Areolar tissue between rectum and prostate (in excess in this specimen). C. Visceral layer of pelvic facia. D. Layer of pelvic fascia covering posterior surface of prostate. E. Layer of pelvic fascia on lateral aspect of prostate. F. Reflexion of E from prostate. G G. Levatores ani. H. Layer of fascia on anterior aspect of prostate. I. Vein of prostatic plexus between layers of H. K. Striped muscle. L. Capsule of prostate. M. Gland tubules near surface of capsule. N. Anterior commissure. O. Urethra, shewing verumontanum. P. Ejaculatory ducts. NOTE.—D E H. Sheath of prostate.

the levatores ani muscles laterally, the rectum posteriorly with a varying amount of areolar tissue interposed, and anteriorly a space (the space of Retzius), bounded in front by the pubic

bones, and laterally by the reflexions of the lateral layer of the prostatic sheath, and containing the dorsal veins of the penis and some areolar tissue.

Under the microscope this fascial sheath consists of wavy layers of fibrous tissue which, although they are in many specimens loosely arranged, can be readily traced and dissected as a definite strong membrane.

The fascia covering the front of the prostate and uniting the lateral layers is thicker on dissection than the rest of the sheath. Its layers are separated by the passage of large veins, which pass upwards towards the base of the prostate. Strands of unstriped muscle are found in this layer, and adipose tissue and medullated nerve-fibres may also be observed. Although much thicker, this anterior layer is less regular in its structure than the rest of the sheath.

The relations of the base of the prostate are important. The outer longitudinal layer of bladder muscle is attached to the capsule of the organ, and some of its fibres become incorporated with this layer.

The capsule, which will later be described as the outer margin of the stroma of the gland, is present on the vesical surface. Directly upon the capsule lies the sphincter of the bladder, which in my sections appears as a broad flat band of circular muscle readily distinguished from the rest of the circular coat. Above this the bundles of the internal longitudinal layer of bladder muscle stream towards the urethra, and, as Thompson has shewn, pass into the wall of that tube. This inner layer is strongly reinforced by two bands of muscle, which pass down from the ureters and meet on the posterior wall of the vesical outlet.

If the apex of the prostate be examined it will be found to be completely surrounded by a layer of striped muscle for about a quarter of an inch. This muscle is continuous below with the constrictor urethræ. Passing upwards from the apex the fibres are attached laterally to the fascia, and only cover the front of the gland for a short distance.

If an incision be now made through the lateral layer of the sheath this fascia can be stripped off the prostate, and the handle of a scalpel can be passed backwards between the sheath and the prostate across the middle line. On stripping the

sheath forwards, however, it is found to be adherent to the prostate along the middle line anteriorly. On cutting through this and turning the sheath upwards the line of adhesion is seen to extend upwards as far as the base of the gland. This band is found to be largely composed of striped muscle-fibres, and is the continuation upwards between the sheath and capsule of the striped muscle described as surrounding the apex of the gland. Sections of the prostate at right angles to the urethra from the apex upwards shew that this striped muscle surrounds the urethra at the apex. Higher up, where the prostatic gland tissue becomes apparent, the striped muscle-fibres are found in the anterior commissure and on the front of the capsule, and a few may still be seen behind the urethra. Still higher the fibres in the anterior commissure gradually diminish, and a layer of more closely-set fibres becomes evident between the anterior layer of the sheath and the anterior commissure (Fig. 1, K). A layer of striped muscle, varying slightly in different glands, is thus to be found along the front of the prostate, and it is to this that the adhesion of the sheath along the middle line anteriorly is due.

Henle described this muscle under the name of the Sphincter Vesicæ Externus.* He did not, however, lay stress upon the concentration of the fibres beneath the sheath, and my attention was first drawn to this layer by finding a mass of striped muscle on the front of an enucleated prostate.

The Prostatic Capsule.

Like other glands in the body which are enclosed in fascial envelopes, the prostate has a proper capsule, which is a part of the connective-tissue framework of the gland (Fig. 1, L). This capsule is directly continuous with the stroma, and is similar in structure. It is composed for the most part of unstriped muscle-fibres, which differentiates it very clearly from the fibrous sheath. The capsule is inseparable from the organ by dissection. It varies in thickness in different glands and also at different parts of the same gland. At some parts the gland tubules approach the surface so nearly as to leave only a narrow margin of unstriped muscle between the tubules and the fibrous

* Eingeweidlehre, 1866.

sheath (Fig. 1, m); at other parts the gland tubules lie far back from the surface, and a distinct margin of stroma is seen representing the capsule.

The Prostatic Venous Plexus.

On examining the anterior layer of the sheath two or more openings leading into venous channels may be seen. These represent the backward continuation of the dorsal veins of the penis, which go to form the prostatic venous plexus. These veins course upwards in the anterior layer of the prostatic sheath to the base of the gland, and then pass backwards on each side around the junction of the bladder and prostate, forming roughly a letter Y with a vertical stem and horizontal arms.

On examining sections of the prostate it is seen that the veins of the vertical part of the plexus lie between the layers of the anterior part of the sheath (Fig. 1, i). They do not, therefore, come into direct relation with the prostatic capsule.

Further, the striped muscle already described between the capsule and the sheath sometimes forms a comparatively thick layer in this situation, and further separates the veins from the prostate (Fig. 1, k). Vertical sections of the prostate and bladder appeared to indicate that the larger venous channels passing backwards on each side did not come into immediate relation with the prostate, but were situated somewhat higher up. Smaller veins were, however, found close to the base of the prostate between the layers of the sheath.

It will be seen therefore that the relation of the prostatic venous plexus to the prostate is less intimate than had been supposed, and that it is possible, even in the normal gland, to strip off this fascial covering without injuring any of these venous channels.

The distribution of Gland Tissue.

Horizontal sections shew that the gland tissue varies at different levels. At the apparent apex of the prostate no gland tissue is present, the urethra being surrounded by muscular tissue, which is largely composed of striped fibres.

At a slightly higher level gland tissue is found on each side of the urethra.

Still further up the amount of gland tissue on each side of the urethra increases, and the canal lies a little nearer the posterior than the anterior surface. Behind the urethra at this level is a thin band of gland tissue uniting the lateral lobes.

At the level of the verumontanum the gland tissue lies on either side and behind the urethra. The tubules are found in greatest abundance on each side of the canal, and extend forwards well in front of it. Directly anterior to the urethra, however, the lateral masses of gland tissue are separated by a broad wedge of fibro-muscular tissue (Fig. 1, N). Behind the urethra at this level there is a broad track of gland tissue uniting the two lateral masses. The ejaculatory ducts and sinus pocularis, surrounded by a layer of unstriped muscle tissue, are seen passing backwards for a short distance (Fig. 1, P). If a prostate be cut obliquely upwards and backwards along the line of these ducts they will be seen to separate the lateral masses of gland tissue into two distinct lobes.

On cutting horizontal sections of the upper part of the prostate, however, a band of gland tissue again appears above the ejaculatory ducts and unites the upper poles of the lateral lobes. At the upper limit of the organ the gland tissue is thus in the form of a horse-shoe, open in front.

It will thus be seen that the gland tissue is arranged in two masses, one on either side of the urethra, and that these are connected behind the urethra by a thin band of gland tissue. This posterior band is tunnelled by the ejaculatory ducts and sinus pocularis, with a surrounding layer of unstriped muscular tissue, from the level of the verumontanum upwards and backwards.

The posterior band uniting the lateral masses above the ejaculatory ducts corresponds to the median lobe of Sir Everard Home. There was no separation of this portion into a special lobe in my specimens, and the condition found was in agreement with Sir Henry Thompson's statement that if a separate lobe existed in this region it was a pathological product. In front of the urethra, along the whole length of the prostate, is a vertical band of tissue composed of unstriped muscle. This wedge separates the anterior part of the two lateral masses of gland tissue. This anterior commissure was present in all the

specimens examined, although it varied somewhat in breadth, and in one specimen almost disappeared at the level of the verumontanum. A few isolated gland tubules were present in the anterior commissure in some specimens, and seemed to open on the anterior wall of the urethra.

Some isolated striped muscle-fibres are found embedded in the unstriped muscle of the anterior commissure. These are most marked at the lower part of the gland. They diminish and finally disappear about the level of the verumontanum. The massing of similar striped fibres beneath the sheath has already been noted.

The urethra in traversing the prostate passes downwards and slightly backwards. At the upper extremity of the gland the canal is in the same plane as the anterior borders of the lobes. At the verumontanum it lies in the centre, and at the lower limit of gland tissue it is nearer the posterior surface.

So far as I could ascertain from my specimens no gland ducts opened into the urethra between the part immediately adjacent to the verumontanum and the membranous urethra. It is therefore apparent that the connection between the prostate and the urethra at the level of the verumontanum and above this eminence is intimate, but that below this level the two structures merely come into relation with one another. The importance of this observation will be seen in examining the extent of the prostatic urethra usually removed at the operation of prostatectomy.

The Seminal Vesicles.

Before leaving the normal anatomy it is necessary to note the position of the seminal vesicles, for the relations of these bodies are altered in the enlarged prostate.

The layer of recto-vesical fascia which encloses the vesicles passes downwards to form the posterior layer of the prostatic sheath. The vesicles lie along the upper border of the posterior aspect of the prostate, but in my dissections, instead of passing almost directly upwards, they took a transverse direction and only curved upwards at their extremities. They thus formed a transverse band lying below the trigone of the bladder.

II.—SOME CHANGES IN THE PROSTATE AND ITS RELATIONS IN ENLARGEMENT OF THE ORGAN.

It is not my intention to discuss the varieties of minute structure or the ultimate pathology of the enlarged prostate; only such changes as immediately concern the operation of prostatectomy will be described.

1. *Changes in the Sheath and in the relations of the Prostate to the Sheath.*

A very considerable increase in thickness is apparent in the sheath of the enlarged prostate. The sheath of the normal prostate, although it may be dissected as a continuous layer of fascia, shews under the microscope numerous planes of wavy fibrous tissue interspersed with loose areolar tissue. In the enlarged prostate the actual thickness of this membrane is increased, and in addition the layers are more compact, so that on making sections for microscopic examination the microtome-knife cuts with difficulty through the dense fascia.

I have already noted that the sheath may readily be stripped off the prostate by dissection except at certain parts. It is, however, a very different matter when an attempt is made to enucleate a normal prostate through a suprapubic wound.

The points of greatest difficulty in making the attempt are found to be, in the first place, in penetrating the bladder base to reach the prostate. Further difficulties are met with in the normal gland at its postero-lateral horns, where the principal vessels and lymphatics enter and leave, at the ejaculatory ducts, along the anterior surface, and at the apex of the gland. Apart from these, however, the normal gland is pretty firmly set in its sheath by fibres passing to and fro between the sheath and capsule, so that it is well-nigh impossible by taking a thick slice of prostate and its surroundings from a fresh body to shell the prostate from its sheath without some damage to both.

In the enlarged prostate, however, the process of enucleation is in most cases easy. The finger in the bladder strips the mucous membrane off the intravesical projection, and passing without effort into the line of cleavage can be swept round each lobe. Again, if a morbid specimen of enlarged prostate be cut at right

angles to the urethra, and another specimen in a vertical direction, the prostate and its capsule can be separated with a little care from the sheath, so that the line of cleavage passes between these two structures.

Some change must therefore take place in the relations of the prostate to its surroundings which permits of the enucleation of the enlarged organ.

As the prostate enlarges the sheath must gradually become stretched, and this stretching would no doubt continue so long as the size of the prostate increased were the gland enclosed within a closed sac of fascia. The prostate, however, merely lies in a cup of fascia, the mouth of which is covered over by the muscular bladder base. The relation of a greatly enlarged prostate to the sheath of pelvic fascia resembles that of an egg to an egg-cup, and in many cases the attachments between the two are very slight.

With the increasing bulk of the enlarging prostate expansion takes place in its circumference and in its length. The increased circumference expands the sheath, and is recognized clinically by enlargement of the organ as felt from the rectum. The longitudinal growth is resisted by the triangular ligament and finds its outlet on the bladder floor, projecting upwards into the bladder cavity. These changes proceed simultaneously, and often to an equal extent. Thus the enlarged prostate may form a prominent mass in the rectum, and at the same time protrude well into the bladder cavity. On the other hand, the expansion of the prostatic sheath may be slight, while a large mass protrudes into the bladder. The rarer cases appear to be those in which a considerable enlargement of the organ has occurred and is wholly extravesical.

Certain portions of the prostate may enlarge while the rest of the organ, although it shews pathological changes, is but slightly increased in bulk. Thus a nodule may protrude into the bladder while the remainder of the organ does not increase in size, or one lobe may shew considerable enlargement while the other lobe remains comparatively small. I could find no explanation of these varieties of growth in my specimens. The sheath of a prostate with a small extravesical and large intravesical enlargement did not appear thicker or tougher than in other enlarged prostates.

One fact appeared to be almost certain, that in the majority of cases the enlargement bladderwards was in no way secondary to the extravesical increase in circumference; in other words, that the prostate did not first of all fill up its sheath and then protrude into the bladder from lack of extravesical space. The growth in length and in circumference appeared to be, in many cases at least, independent, although frequently simultaneous.

With the increased bulk of the enlarged prostate there appears to be a loosening of its connections with its sheath. This has been called by Mr. Freyer a "shaking free" of the enlarged prostate, and upon it much of the ease with which the operation is carried out depends.

In the specimens I dissected no microscopic change could be demonstrated which would shew that this process had taken place. The capsule of the organ certainly appeared somewhat denser and more readily distinguished from the sheath, but there was no line of separation between the two structures. In the gross specimen, however, the gland and capsule could be separated from the sheath with greater ease than in the normal gland.

Another important change takes place in the relations of the enlarging prostate and its sheath. The upper part of the posterior surface of the gland already lies in an angle between the bladder base and the lower border of the seminal vesicles. As enlargement of the organ proceeds this wedge begins to insinuate its bulk between the bladder wall and the vesicles so that these structures become more and more separated. The vesicles are pushed further and further back, and are at the same time stripped from the bladder wall, until finally they lie behind the upper part of the gland instead of above it. They thus form the upper part of the posterior wall of the sheath. This change may be seen on examining sagittal sections of enlarged prostates. It is still more evident when post-mortem specimens of the prostatic sheath after prostatectomy are dissected. In such cases the peritoneal pouch of Douglas retains its normal relation to the vesicles, and thus becomes a posterior relation of the enlarged prostate.

While this pushing backwards of the vesicles takes place in the majority of enlarged prostates, there are some in which the relation of these structures to the bladder base is undisturbed.

In one post-mortem prostatectomy the vesicles were found in their normal position, and the prostate had pushed upwards between the vesicles and the rectum as high as the recto-vesical pouch of peritoneum.

2. *Changes in the relation of the Prostate to the Bladder.*

The changes in the relation of the enlarged prostate to the bladder base are important surgically.

In the greater number of cases of enlarged prostate some portion of the enlargement protrudes into the bladder cavity. Upon this intravesical portion depends in most instances the need for operation; and further, the ease with which the operation of prostatectomy is carried out is to a considerable extent influenced by the presence of an intravesical protrusion.

I examined fifty-four specimens of the above series of enucleated prostates with the view to ascertaining the origin of the intravesical projection, with the following results :—

Median lobe alone - - - -	9
Median and lateral lobes :	
Three lobes distinct - - -	2
Fused collar - - - - -	12
Median and left lobe - - -	2
Median and right lobe - - -	2
Lateral lobes :	
Both lateral lobes - - -	15
Left lateral lobe only - - -	9
Right lateral lobe only - - -	3
	54

The form which the intravesical portion took shewed an almost endless variety. In the smaller specimens—those weighing about one ounce after removal—the most marked change was the extension upwards into the bladder of a collar of prostatic tissue around the urethra, or of a nodule from the median portion behind the urethra. The median projection when arising from the median portion was in most instances small. The larger outgrowths from this portion were either pedunculated or fused with intravesical lateral lobes. In the

larger specimens the ingrowth into the bladder was in the form of one, two, or three lobes, or as a large fused collar, which was rolled over backwards on the base of the bladder.

In three specimens the left lobe alone projected into the bladder, and the intravesical portion was bent around the vesical outlet beneath the mucous membrane in a sickle-like form.

In a few specimens of considerable size only a small nodule protruded into the bladder. The bulk of the intravesical portion was equal to the extravesical in many cases, and in a few greatly exceeded it.

In some of the larger specimens small outlying nodules were found connected with the main intravesical mass by fibrous pedicles.

On examining the intravesical protrusion of enlarged prostates it is found that they are covered only by mucous membrane, which lies directly upon the capsule.

It has already been noted that the base of the normal prostate is covered by a layer of circular bladder muscle, and this again by the inner longitudinal layer of muscle which passes into the urethral wall. In order to reach this position under the mucous membrane of the bladder base the intravesical nodules must have burst through this muscular barrier. In these cases a portion of the upward growing prostate insinuates itself within the circle of the vesical sphincter. The sphincter becomes more and more widely dilated, and in the prostates which have a large intravesical protrusion it forms a wide circle, enclosing within its grasp a mass of prostatic tissue around which the thumb and forefinger can barely meet. The sphincter thus pressed back does not atrophy as might be expected. Its fibres, partly from being crowded together, and partaking also, no doubt, in the general muscular hypertrophy which affects the bladder wall, are more compact and better defined than those of the normal sphincter.

Coincident with this continuous dilatation of the bladder sphincter there is an upward pressure against the sheet of longitudinal muscle fibres, which is spread over the trigone and passes into the urethra At one point or at several the fibres of this layer separate and allow a nodule of prostatic tissue to appear immediately under the bladder mucous membrane.

Should this nodule protrude into the bladder between two strong bands of longitudinal muscle, it is not unlikely that it may become pedunculated.

In similar manner the well-known middle lobe is formed. The absence of a middle lobe in the normal prostate has already been commented upon. The upper surface of the prostate is in the form of a horse-shoe around the back and sides of the urethra, and often protrudes into the bladder in this form. Laterally this corresponds to the upper poles of the lateral lobes, and in the middle line posteriorly to that portion under which the ejaculatory ducts tunnel. There is, however, no separation of this median posterior portion from the lateral portions. Why, then, do we so frequently find a median projection of the prostate behind the urethra when the organ enlarges?

In the table already given of the origin of the intravesical projection of fifty-four enucleated prostates, it is seen that the median portion alone was the origin of this growth in only nine specimens. This does not, however, represent the total number of specimens in which a median lobe was present. In the others, however, the origin of the posterior median projection was not solely, or not at all, from the median posterior portion of the prostate. The proportion of enlargements of this median portion has, I believe, been greatly overstated, and this is due to the fact that many enlargements which have a median posterior position are in reality outgrowths from the lateral lobes. I cannot, however, go so far as some and state that the median lobe arising from the median portion of the prostate does not exist. In many cases the enlargement was formed apparently of a fusion of the outgrowths from one or other lateral lobe with that from the median lobe. But apart from these, there were not a few cases in which, with a minimal enlargement of the lateral lobes, a nodule projected into the bladder behind the urethra, the origin of which was undoubtedly the median posterior portion of the prostate. It is therefore necessary to look for some structure outside the gland itself which influences the production of an intravesical nodule in the middle line behind the urethra, whether that nodule arise from the median or lateral lobes. This, I believe, is to be found in the arrangement of the fibres of the internal longitudinal layer

of bladder muscles as it passes into the urethral wall. A band of muscle is contributed by the ureter of each side to the inner layer of bladder muscle, and these two bands converge towards the urethra and pass into the wall of that tube with the other longitudinal fibres. The upward growth of the prostate will tend to separate these bands, and, having done so, a projecting button will be formed in the middle line posteriorly which, on further growth, may become pedunculated by the pressure at its base by the two bands. Enlargement of one lateral lobe may of course project outside these bands, and this form of intravesical projection is not infrequent; but if the upward enlargement of the lobe tends to spread medianwards, or if the median portion is involved in the process, the tendency appears always to be for the growth to burst through the longitudinal layer of muscle in the middle line posteriorly between these two bands. In the specimens of enucleated prostate where a single median lobe is present, strong bands of non-striped muscle are found passing down on either side of this lobe to join the urethral muscle. Where the intravesical portion consists of projections from the lateral lobes as well, these bands will be found to separate the three intravesical nodules. Where the lateral lobes only project as separate nodules into the bladder, this longitudinal muscle will be found crowded together in the median posterior cleft between the nodules.

3. *Changes in the Prostatic Urethra.*

The changes in the urethral form, length, and calibre are perhaps the most varying factors in the structural alterations which take place in enlargement of the prostate.

The muscular wall of the urethra appears to be thinner in the enlarged prostate than in the normal gland. This is no doubt caused by the antero-posterior and longitudinal stretching of the tube, which results from the increased bulk of the prostate. The epithelium of the mucous membrane is also thinned, so that in many specimens it is represented merely by one or two layers of low cubical cells.

As the enlarging prostate begins to project through the lumen of the vesical sphincter it drags up the urethral mucous membrane with it into the bladder. The junction of the bladder mucous membrane with that of the urethra can be distinguished

without difficulty in most cases of enlarged prostate. In very large intravesical growths it is, of course, impossible to distinguish urethral from vesical mucous membrane, but in the smaller ingrowths and collarlike enlargements there is no difficulty in recognizing the line of junction. This line is usually placed on the vesical aspect of the nodule or rim, and not on its urethral aspect. The intravesical enlargements are, therefore, covered in part at least by mucous membrane derived from the prostatic urethra. I believe that this exposure of urethral mucous membrane to the urine may explain the frequency of micturition, which is such a constant and distressing symptom in cases of enlarged prostate, quite apart from such complications as cystitis or calculus.

The elongation and varieties of change in contour of the prostatic urethra are too well known to dwell upon here. One point is, however, very striking in examining specimens of enlarged prostate. The elongation affects that portion of the urethra lying between the bladder orifice and the verumontanum, and hardly at all the part beyond this. If the wall of the cavity from which the enlarged prostate has been removed be examined post-mortem, it is found that the increased capacity required for the extravesical portion of the enlarged prostate is obtained almost entirely at the expense of the structures abutting upon the upper portion of the gland, and that little or no change has occurred at the lower part. The position of the ejaculatory ducts remains unchanged, and they are found near the lower part of the wall of the cavity. From these facts it is apparent that the enlargement of the organ affects principally the portion lying above the level of the ejaculatory ducts and verumontanum.

There are, however, a few prostates in which the glandular substance below the ejaculatory ducts is the seat of marked enlargement. In such cases the ejaculatory ducts and seminal vesicles retain their normal relations to the bladder wall and to the prostate as a whole.

The change in the shape of the urethra into an anteroposterior slit is well known, but there is a very marked change in the relation of the urethra to the prostate as a whole, which has not, so far as I am aware, been pointed out. This change consists in the backward sinking of the posterior wall of the

urethra between the prostatic lobes. In the normal prostate, at the level of the verumontanum, the urethra is situated about midway between the anterior and posterior surfaces. In a similar section of an enlarged prostate it is found that the posterior wall of the urethra has passed backwards between the lobes, and now occupies a position at the posterior surface with little or no gland tissue behind it. This change is greatest at the level of the verumontanum. If an enlarged prostate be cut antero-posteriorly so that the urethra is split open along its anterior and posterior walls, the anterior wall will be found to be almost straight. The posterior wall, however, passes from the vesical outlet downwards and backwards to the level of the verumontanum, and from this almost directly forwards. A deep pocket is thus formed in the posterior wall with its apex at the verumontanum. The structure which appears to me to play the most important part in causing this change is the fibrous and muscular band which surrounds the ejaculatory ducts. This band finds attachment at the verumontanum at one end and at the seminal vesicles at the other. It has already been noted that the seminal vesicles are stripped from the bladder wall and forced backwards by the enlarging lobes. This must exercise a continuous backward drag on the posterior wall of the urethra and tend to tear it from between the prostatic lobes.

III.—THE STRUCTURES REMOVED AT THE OPERATION OF PROSTATECTOMY.

In examining the series of prostates removed by enucleation they were found to vary in three important particulars. The weight of the smallest was but three-quarters of an ounce, while the largest weighed $10\frac{1}{4}$ ounces. Size did not, however, form a convenient basis for classification for the purpose of the present investigation; for although, as a general rule, the larger growths are more easily enucleated than the smaller, yet there are considerable variations in the ease with which the operation is carried out, which are dependent upon other factors than the size of the enlarged organ.

In some of the specimens the two lobes were bound together by a continuous capsule, while in others the capsule was ruptured along the anterior surface, so that the lobes could be

separated and remained united merely by a posterior hinge. This was, however, the accidental result of operative manipulation and could not be regarded as a fundamental difference.

I have already pointed out that the relation of the enlarged prostate to the bladder base has an important influence upon the ease with which the operation is carried out; and moreover, the protrusion of a nodule of prostatic tissue into the bladder is an anatomical point of some importance.

It is possible in the specimens of enucleated prostate to distinguish those which were extravesical from those which had protruded into the bladder, and I have therefore classified them under these two headings. The relative size of the prostates did not correspond so closely with these groups as one would expect on theoretical grounds. Among the prostates which were totally excluded from the bladder were some weighing between two and three ounces, while among those which possessed an intravesical portion were specimens weighing as little as three-quarters of an ounce.

1. *Prostates which protrude into the Bladder.*

A typical example of an enucleated prostate which has protruded into the bladder will first be considered. The intra- and extravesical portions are readily distinguished. Between these two portions a groove surrounds the specimen and is deepest on the right side, becoming shallower posteriorly and on the left side (Fig. 2, E).

The extravesical portion, which was contained in the prostatic sheath, consists of two lobes completely surrounded by a layer of tissue (Fig. 2, A). This coat consists of circularly disposed bundles of tissue. The bundles are comparatively fine, and the general surface is smooth and regular. The coat is complete except at one part where a small transverse tear has exposed a subjacent nodule of prostatic tissue.

At the lower end of the specimen—that is, the part which abutted upon the triangular ligament—the lower pole of each lobe is indicated, and between these is the opening of the lower end of the prostatic urethra (Fig. 2, C). The fibres of the capsule dip in here and pass up along the wall of this canal. Posteriorly the capsule uniting the lobes passes down to their

extreme limit. At the upper part of the extravesical portion of the specimen there is a well-marked thickening of this capsule, which is most apparent in the deep groove on the right side of the specimen.

In the middle line anteriorly is a strand of fibres which have been torn across (Fig. 2, D). These fibres, which extend along the middle line anteriorly for about three-quarters of an inch, have evidently formed a band of adhesion with the tissues that have been left behind.

Fig. 2.—Enucleated Prostate: Anterior View.

A B. Right and left lobes. C. Catheter in urethra. D. Ridge of striped muscle. E E. Groove separating intra- and extra-vesical portions. F. Middle lobe. G G. Deep grooves, in which lie bands of muscle.

The intravesical portion of the specimen is marked off from the rest by a groove. It consists of three large nodules surrounding the vesical opening of the urethra, behind and on each side; only a small amount of prostate tissue appears in front of this opening. In the middle line posteriorly is a large rounded nodule representing a middle lobe, and this is separated from

the lateral portions by grooves (Fig. 2, G). In the grooves are found bands of tissue which have evidently been torn across at their upper ends. These bands on microscopic examination consist of non-striped muscle, and can be traced downwards into the urethral wall. The capsule which surrounds the extravesical portion is continued upwards over the intravesical portion, but is much thinner over the middle and right lobes. The ejaculatory ducts cannot be detected in this specimen.

A section at right angles to the urethra, at about the middle of the extravesical portion, shews two well-defined lobes, which consist of numerous rounded nodules of adenomatous prostatic tissue. A dense capsule surrounds both lobes and binds them together (Fig. 3, A). This capsule consists of circularly-arranged fibres, and is thicker in front than at the sides. The urethra

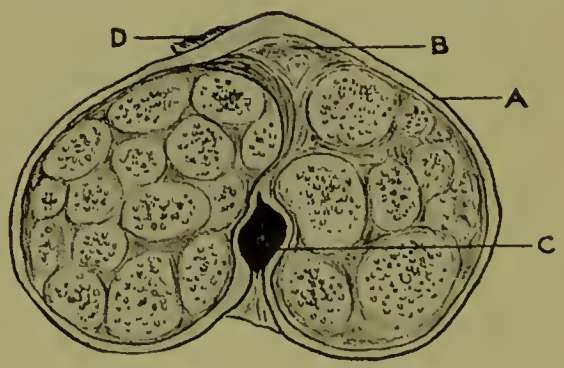

Fig. 3.—Section of Enucleated Prostate at Middle of Extravesical Portion.

A. Capsule. B. Anterior commissure. C. Urethra. D. Striped muscle.

lies between the lobes, and its posterior wall is only separated from the surface of the specimen by a thin layer of tissue (Fig. 3, C). A section at the junction of the extra- and intravesical portions shews that the left lobe forms a large adenomatous mass to the left of the urethra, while the right lobe is not seen at this level. The capsule is here represented by a much thicker band, which on the right of the urethra, over the position of the upper pole of the right lobe, forms a broad, dense mass of tissue. The urethra is displaced forwards and to the right. A section through the intravesical portion shews the urethra still further forward, and surrounded behind and on each side by a continuous collar of adenomatous tissue, the largest mass of which is on the left side (Fig. 4). The gland tissue is here, as elsewhere,

completely surrounded by a firm capsule. It is therefore evident that the right lobe is wholly extravesical, and that the intravesical portion is formed by the upward continuation of the left lobe, which has become bent around the urethral opening in the form of a horse-shoe.

A microscopic section through the entire mass at the middle of the extravesical portion shews the following points of interest. Each lobe is subdivided into numerous lobules by rings of fibrous tissue, and these lobules shew the usual cystic adenomatous formation found in enlarged prostates. A band of fibres leaves the capsule anteriorly and dips in between the anterior borders of the lobes, passing backwards

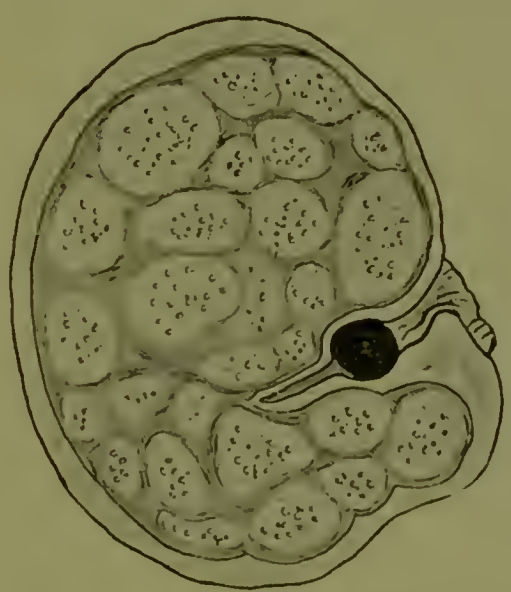

FIG. 4.—SECTION OF INTRAVESICAL PORTION OF SAME PROSTATE.

Note the capsule surrounding the whole mass, and the position of the urethra.

on each side of the urethra to join the capsule again posteriorly. This gives the appearance of a special capsule to each lobe. Between the lobes in front of the urethra is a wedge of unstriped muscle and fibrous tissue. This represents the anterior commissure. An isolated nodule of gland tissue is found embedded in its substance. From the urethra a line of cleavage passes forwards, but does not reach the surface. It is apparent that a slightly greater degree of force at the time of the operation would have burst the two lobes asunder anteriorly.

The urethra is elongated antero-posteriorly and displaced to the right of the middle line. The verumontanum is seen on its posterior wall, which lies near the posterior surface of the lobes, with no glandular tissue behind it. The muscular wall of the urethra is relatively thin as compared with that of the normal organ; the layers of which it is composed are, however, more distinctly defined from the stroma of the gland. The epithelium lining the urethra, in this specimen, has not suffered from the elongation of the tube, but in other specimens it is thinned out, and in some parts merely represented by a single layer of cubical cells.

FIG. 5.—SECTION OF CAPSULE SURROUNDING ENUCLEATED PROSTATE.

a. Adenomatous prostatic tissue. *b*. Non-striped muscle forming capsule. *c*. Perivascular round cell infiltration.

The ejaculatory ducts are seen passing backwards from the verumontanum, and are torn across a short distance from the urethra. The whole length of the prostatic urethra is represented in this specimen.

The capsule is composed of densely-packed layers of unstriped muscle-fibre (Fig. 5, *b*). The fibres are long and their characteristic nuclei are well stained and distinct. Here and there a blood-vessel is found, and this is usually surrounded by an area of round cell infiltration (Fig. 5, *c*). Some of these vessels shew hyaline changes in their walls. The perivascular round cell infiltration may be found in lines between the muscular bundles, and sometimes resembles compressed gland tubules. At some part of the capsule there is not infrequently found one or several flattened gland tubules embedded among the layers of non-striped muscle. I have looked for an explanation of these gland tubules in the normal gland, and have found that the capsule here varies greatly in thickness, and at some parts gland tubules approach very near the surface (Fig. 1, M). It seems likely that these more superficial gland tubules may be caught up in the capsule and compressed as the prostate enlarges.

Attached to the capsule a little to the left of the middle line is a mass of striped muscle-fibres (Fig. 6, *a*). The fibres are separated from one another by loose areolar tissue. In the capsule isolated striped muscle-fibres are also found lying embedded here and there among the layers of unstriped muscle (Fig. 7, *a*). The tuft of striped muscle on the front of the capsule corresponds to the vertical band of torn fibres described on the anterior surface of the specimen. This represents the layer of striped muscle which has been described lying between the capsule and the sheath of the normal organ. The striped fibres lying in the capsule are, I believe, the remains of these fibres which are present in the anterior commissure and capsule of the normal prostate. It is noteworthy that those on the front of the capsule are embedded in areolar tissue, while those in the capsule lie among the non-striped muscle tissue.

On the front of the capsule in the neighbourhood of the tuft of striped muscle a few medullated nerve-fibres are found. In my sections of normal prostates I have not found medullated nerve-fibres in the capsule or stroma of the gland, although they are plentiful in the sheath; nor have I found in the literature any description of medullated nerve-fibres piercing the capsule of the prostate. It would appear, therefore, that these nerve-fibres must have been torn from the sheath during the enucleation.

2. *Enlarged Prostates which are Extravesical.*

These form a much smaller group than the prostates which have penetrated into the bladder. The description of the extravesical portion of the prostate already given applies to this group. The upper limit of the specimen is at the level of the deep groove described above. The upper poles of the lobes are

FIG. 6.—RIDGE OF STRIPED MUSCLE ON ANTERIOR SURFACE OF ENUCLEATED PROSTATE.

a. Striped muscle-fibres embedded in areolar tissue. *b*. Non-striped muscle forming capsule.

covered by the capsule, and at the upper opening of the urethra, especially at its posterior aspect, the longitudinal fibres of the bladder muscle are found torn across at the point at which they enter into the urethral wall. This sometimes amounts to a

thick rim of muscular tissue. The outline of these extravesical prostates is always more regular than those in the first group. They shew two usually equal lobes much larger than the normal prostate in size, but resembling its outline in other respects, except that the vesical end of the organ is more pointed and less a flattened surface.

Once the prostate bursts into the bladder there is nothing to define and mould its growth, and the outline of the intravesical portion is therefore frequently irregular and sometimes even fantastic in its contour.

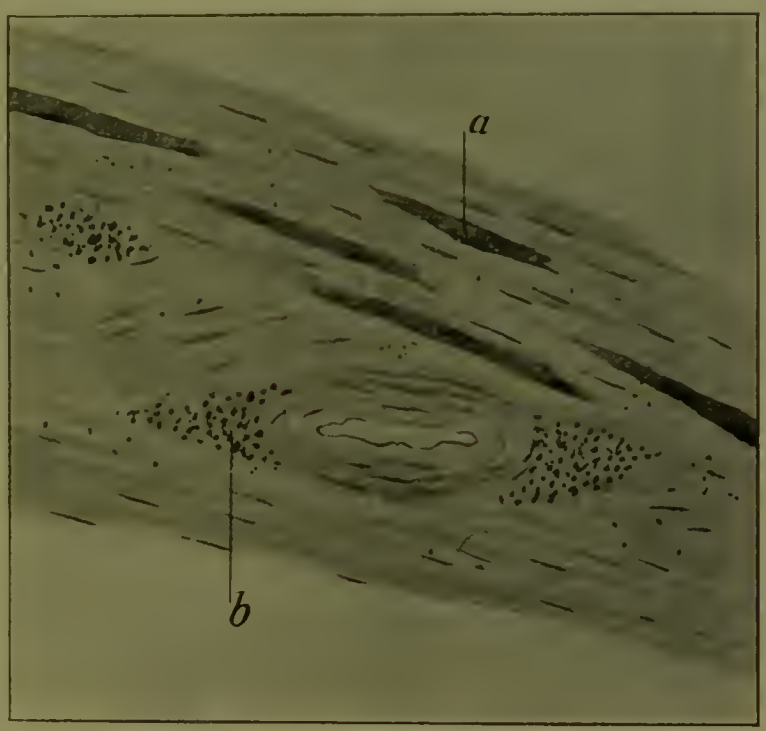

Fig. 7.—Striped Muscle-fibres in Anterior Part of Capsule of Enucleated Prostate.

a. Striped muscle-fibre embedded in non-striped muscle of capsule. *b*. Perivascular round cell infiltration.

Variations in the Enucleated Prostates.

There are certain points which may be noted in regard to specimens belonging to either of these groups.

In many specimens the capsule and anterior commissure have given way and allowed the lobes to become separated along the middle line anteriorly. The line of cleavage in these cases

passes from the urethra forwards, and the mass of tissue representing the anterior commissure is left adhering to one or other lobe. These open prostates do not differ materially from the closed variety, of which an example has been described. They formed the majority of the specimens. In fifty-nine enucleated prostates fifty-one were open anteriorly and only eight closed. Open prostates were found among the intravesical as well as the extravesical forms.

This bursting of the lobes asunder anteriorly results from manipulation during the enucleation. It may be produced designedly by forcing the finger into the prostatic urethra at the commencement of the enucleation, and sometimes assists the process of shelling out the prostate. It appears to some extent, however, to depend upon the strength of the capsule and anterior commissure, for, in the closed variety of enucleated prostates, the capsule usually appears thicker than in those in which the lobes are separated anteriorly.

In three specimens the lobes had been enucleated separately, the urethra having been torn through along its anterior and posterior walls.

Certain variations in the capsule require notice.

The strongest part of the capsule is undoubtedly the part which surrounds the lobes above the level of the ejaculatory ducts. In some of the specimens the band was of considerable thickness and appeared to be almost a distinct structure from the rest of the capsule. This thick band is due, I believe, to the addition of muscular fibres from the wall of the bladder. The texture of the capsule shewed considerable variation in different specimens. In some it was coarse and the individual bundles were thick. In a few specimens tags of the capsule were torn up and gave the specimen an irregular ragged appearance. It was evident in a few specimens that portions of the capsule were wanting, for the subjacent prostatic nodules were exposed. In one or two specimens a nodule had been torn from the surface of the lobe. It is not surprising that such variations should occur. The capsule covering so large a mass of prostatic tissue as many of these specimens represent must necessarily be somewhat irregular; and moreover, the type of operation—a digital excochleation—is against microscopic perfection in the enucleated specimens. It is rather a matter of

surprise that so many of the specimens are perfect and that the imperfections in the few are so slight. But the portions torn from the prostatic capsule are not necessarily left behind *in situ*. I have already stated that shreds of the capsule may be found free in the prostatic or bladder cavity after the operation. Irregularities of the surface of these specimens do not, therefore, of necessity always represent portions left adherent to the prostatic sheath.

In a few specimens it was evident that something more than the capsule had been removed with the prostate. In one specimen the torn edge of the mucous membrane and muscle of part of the trigone was found adhering to the upper part of the enlarged prostate. In other specimens, which had an intravesical collar or nodule, transverse muscular fibres were found adhering to the posterior or under surface of this. These fibres had evidently been torn from the floor of the bladder immediately adjacent to the vesical outlet. When these fibres were traced downwards they were found to pass into the circular layers of the capsule, and some of them split off and passed round on each side of the intravesical nodule into the wall of the urethra.

The Condition of the Urethra in Enucleated Prostates.

It would be impossible, without submitting each specimen to section and microscopic examination, to state precisely in all cases whether the whole, or a part, or none at all, of the urethra was removed with the prostate. I have been able, however, by comparison of the prostates of which I have made sections with others presenting similar appearances, and by excising portions from open and from closed prostates, and lastly by comparison with the post-mortem specimens which will be described later, to come to some definite conclusions as to the effect of prostatectomy upon the prostatic urethra.

In the first place the entire prostatic urethra may be removed with the prostate. This has been stated to be the case in the closed prostate already described in detail.

The prostates in which this occurs are nearly all of the closed variety. It would, of course, be impossible to remove the unbroken ring of prostate from the urethral tube which pierces it without tearing through the urethra at some part.

The prostatic ring might, however, be slipped off the urethra if the tube were torn across at one part. This is reported to have happened in one case.

Secondly, the whole urethra may be left behind. In these cases the prostate is almost invariably of the open variety. The muscular wall of the urethra is also left behind in these cases, not merely the tube of mucous membrane.

What the condition of the urethra which is wholly left behind at the operation may be, I have only the evidence of one post-mortem examination to shew. In this specimen the urethra was torn across at the level of the verumontanum, and the upper and lower segments were left projecting into the cavity. What the ultimate fate of the prostatic urethra which is left behind after prostatectomy may be, is at the present time a matter for speculation. My impression is that when a living tube of this length is isolated and remains merely attached at each end the lack of blood supply will lead to sloughing, at all events of the central part. It might, of course, be compared with the extensive stripping of the ureter from its connections, or even to the isolation of a portion of an artery, both of which may be carried out without any permanent harm resulting. The cases are not, however, exactly parallel, for each of these tubes carries its own blood-supply, which the isolation of even a considerable segment does not materially damage, and, moreover, the urethra in prostatectomy has been subjected to considerable violence during the operation.

It might be held that the walls of the cavity close around the urethra and the nutrition of the tube is maintained by a collateral circulation through adhesions. An examination of the fascial lining of the cavity does not, however, support the idea that rapid adhesion will take place, and the manipulations during the operation, added to the septicity which is seldom absent from such bladders, are more than likely to forestall any adhesion by causing the death of the tube.

There is a third condition shewn by these specimens. Part of the tube may be removed and part left behind. If one of the open variety of prostates be examined it may be found that the flat inner surface of each lobe for a considerable area is smooth and glistening, and that the lobes are united by a hinge of tissue which binds them together at the upper half of their

postero-internal borders. The anterior surface of this hinge shews a median vertical ridge with smaller ridges converging towards an eminence at its lower extremity. The appearance is that presented by the montanal ridge, and at the lower extremity the eminence of the verumontanum. On microscopic section it is found that the lateral walls of the prostatic urethra line the inside of the lobes, the antero-posterior depth of the urethra being, of course, greatly increased. The hinge uniting the two lobes posteriorly represents the portion of the posterior wall of the prostatic urethra which lies between the vesical outlet and the verumontanum. The portion of the posterior wall which lies between the verumontanum and the membranous urethra, and which I have already shewn passes from the verumontanum almost directly forwards, has been left behind on the floor of the cavity from which the prostate was removed.

I believe that a scrap of capsule is frequently left behind at this part.

This condition is of considerable importance, for, if the posterior wall of this part of the urethra, together with the verumontanum, remains adherent to the wall of the cavity, the ejaculatory ducts need not be injured and the genital portion of the urethra is not destroyed. The intimate connection of the upper portion of the prostatic urethra with the glandular substance by the prostatic duct openings as compared with the lower part of the canal has been commented upon, and may have something to do with the portion of the urethra taken away and that left behind. During the operation of prostatectomy, however, the enucleating finger constantly encounters some difficulty just at the point where the ejaculatory ducts join the urethra, and it may be that this binding down of the urethra by these ducts may commence the tearing of the urethra which results in leaving behind this part of the posterior wall. From the large proportion of these specimens it would appear that this is what most usually happens to the urethra.

In seeking for the ejaculatory ducts in the enucleated prostates they were only found in a few specimens, and in most of these the entire urethra had been removed. When present, the ejaculatory ducts were found torn across, either low down, just below the middle of the posterior surface of the extravesical portion, or quite at the upper limit of this portion. When found

in the latter position it may be inferred that the seminal vesicles retained their normal relation at the upper part of the prostate. When, however, the torn ducts are found low down, the seminal vesicles have probably been stripped from the bladder base and form a posterior relation of the prostate in the manner already described.

IV.—THE PARTS LEFT BEHIND AFTER THE OPERATION OF PROSTATECTOMY.

The material collected for this part of the investigation consisted of four specimens.

Death occurred in these cases in from nine hours to fifteen days after the operation.

Three of the specimens were removed from the bodies in the following manner: The bladder and rectum were first detached, together with the levatores ani, by cutting as close as possible to the pelvic wall. A median incision was then made in the perineum over the bulb and carried back around the anus. The bulb, the perineal muscles, the triangular fascia, and the anus were then dissected from the pelvic outlet, and the whole mass drawn up through the abdominal wound. The bladder and prostatic sheath were then opened along the middle line anteriorly. The remaining specimen was sent to me after removal from the body.

In specimens III. and IV. the presence of a nodule of carcinoma outside the sheath in the former, and of carcinomatous deposit in the lymphatic glands of the pelvis in the latter, shewed that prostatectomy had been performed upon carcinomatous prostates. These specimens might therefore be put aside, were it not that they proved useful for dissection and corroborated certain of the anatomical points found in the others.

I shall describe one specimen in detail and merely refer to differences in regard to the others.

At the upper part of this specimen is the trabeculated bladder (Fig. 8, A), and below this the cavity from which the prostate was removed (Fig. 8, D D).

The vesical sphincter is a well-defined muscular band (Fig. 8, C) and surrounds an aperture of considerable area. This

aperture is notable, as it represents the opening through which the intravesical portion projected into the bladder. In examining the enucleated prostates it was noted that a groove

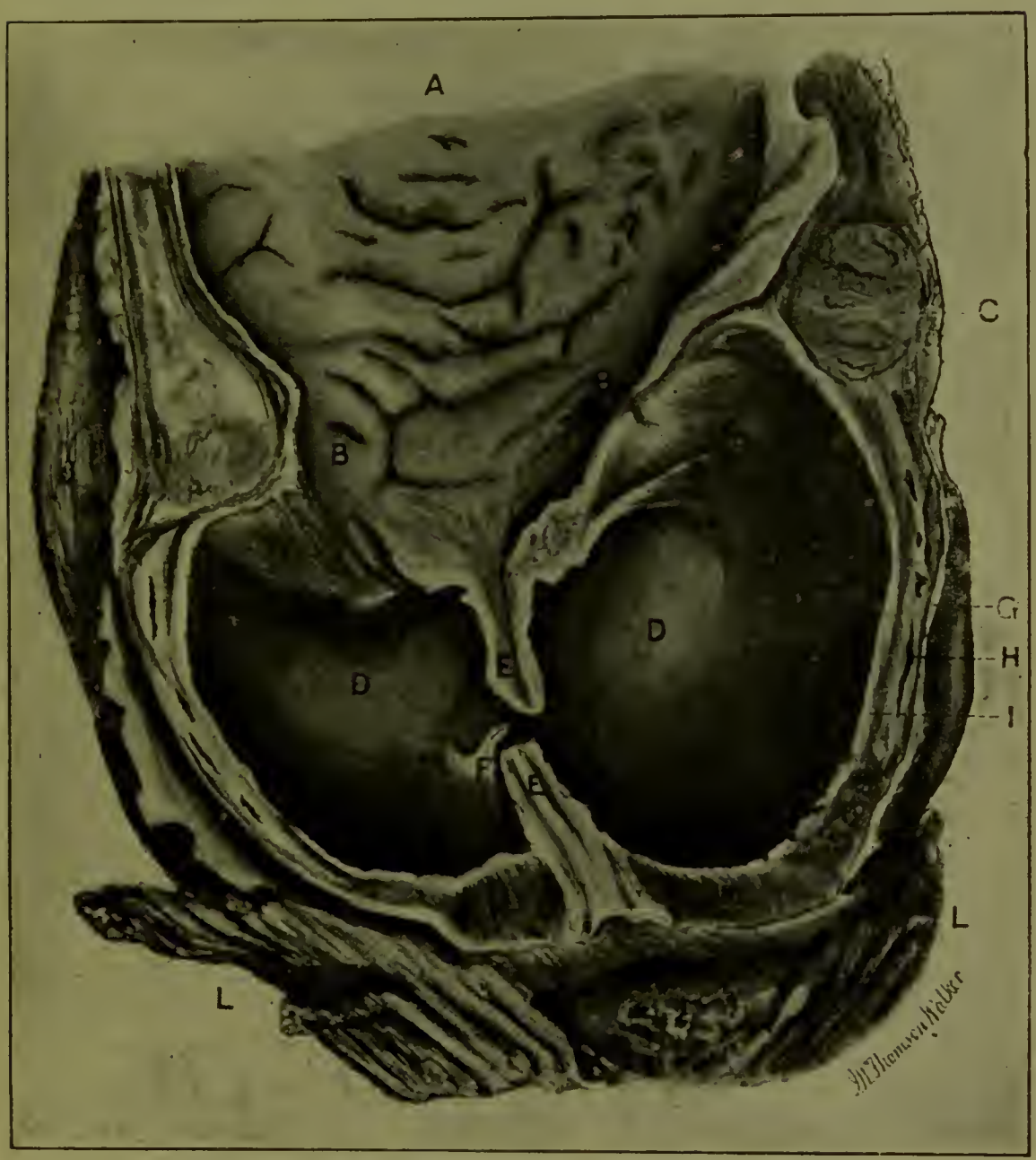

FIG. 8.—POST-MORTEM SPECIMEN AFTER PROSTATECTOMY.

A. Bladder. B B. Openings of Ureters. C. Sphincter of bladder. D D. Cavity, left after removal of prostate. E E. Prostatic urethra torn across at verumontanum. F. Ejaculatory ducts. G. Outer layer of sheath. H. Vein of prostatic plexus. I. Inner layer of sheath. K K. Striped muscle. L L. Levatores ani.

separated the intra- from the extra-vesical portions. This groove is produced by the pressure of the sphincter of the bladder.

In relation to the cavity from which the prostate was removed it is necessary to examine the remains of the urethra and the walls of the cavity.

1. *The Remains of the Urethra.*

From the apex of the trigone of the bladder a tongue of tissue hangs downwards for six-eighths of an inch, and the lower end of this comes in contact with another process of tissue, slightly shorter, which projects upwards into the cavity from the centre of its floor (Fig. 8, E E). This latter process has a median longitudinal ridge.

These processes represent the prostatic urethra, and in this case the whole length of the prostatic urethra has been left behind.

In the second specimen the urethra has been torn across at the junction with the vesical mucous membrane. The lower portion of the posterior wall of the urethra, comprising the verumontanum and the part below this, is present in the specimen, and is bound down to the floor and posterior wall of the cavity.

In specimen III. the urethra has been torn across at the membranous portion, and the whole of the prostatic urethra removed. In addition, a portion of the mucous membrane of the trigone of the bladder has been torn away, and is found adhering to the upper part of the prostate. In specimen IV. the prostatic urethra was removed with the prostate, the mucous membrane being torn across at the vesical opening and at the membranous urethra.

2. *The Walls of the Cavity from which the Prostate has been Removed.*

The space from which the prostate has been removed in specimen I. is a single cavity with an incomplete roof, a flattened posterior wall, and rounded anterior and lateral walls, which pass into each other. Indications of the bilobed form of the prostate can be seen, especially at the upper part of the cavity. The posterior part of the cavity is partly roofed over by an overhanging ledge, which is formed by the muscular bladder base, covered on the vesical aspect by the mucous membrane of the trigone.

From the centre of this ledge hangs the portion of urethra already described. The lining of the cavity is comparatively smooth. Around the upper part is a circular arrangement of fibres continuous with the under surface of the circular fibres of the sphincter. Around the entrance of the urethra, on the floor, there is also a circular arrangement of fibres. Between these sets of fibres the wall is smooth. Springing from the posterior wall, in the median line, rather nearer the floor than the roof, is a process of tissue rather more than a quarter of an inch long (Fig. 8, F). This projects forwards into the cavity and almost meets the upper extremity of the lower urethral segment. This process is composed of the ejaculatory ducts and the surrounding muscular tissue.

The upper end of the portion of urethra left behind in specimen II. corresponds to the verumontanum. The ejaculatory ducts were not found in the remaining specimens.

By dissection of the posterior wall of these specimens it was found that the upper part, including rather more than the upper half, was formed by the seminal vesicles and the lower ends of the vasa deferentia. These were enclosed within their sheath of recto-vesical fascia, and this fascia prolonged downwards formed the lower part of the posterior wall and the floor of the cavity. From within the cavity, however, it was necessary to turn down a thin layer of non-striped muscular tissue before reaching the anterior surface of the upper part of the vesicles. These fibres have already been seen to surround the upper part of the cavity. They thin off rapidly and do not reach the middle of the cavity. At the cut edge of the specimen these fibres may be traced upwards to the circular bladder muscle, and are the prolongation of this layer downwards to join the prostatic capsule.

The lateral walls of the cavity are thinner than the anterior and posterior walls, and the inner surface is smooth. The levatores ani lie on the outer surface of this part of the wall.

Between the layers of fibrous tissue that form the anterior wall of the cavity, the large veins of the prostatic plexus are seen passing upwards (Fig. 8, H). By the unaided eye it is recognized that these veins are protected on the side of the cavity by a layer of this fascia.

On the floor of the cavity surrounding the entrance of the urethra are some circular fibres, which may be traced outwards for a short distance. Under the microscope they are found to consist of striped muscle-fibres loosely arranged. They may be followed to the urethra, and pass out along its wall to join the constrictor urethræ.

FIG. 9.—VERTICAL SECTION THROUGH WALL OF CAVITY AFTER PROSTATECTOMY.

A. Bladder wall. B. Bladder mucous membrane. C. Right half of cavity after removal of prostate. D. Position of urethra. E. Fibrous sheath. F. Vein of prostatic plexus between layers of E. G. Constrictor urethræ. H. Striped muscle on urethral wall. I. Striped muscle on floor of cavity. K. Bladder muscle on wall of cavity. L. Nodule of prostatic tissue.

Microscopic sections of the entire wall of the cavity cut vertically shew the following points:—

At the upper part is the bladder wall, the layers of which are distinct, and passing down from this is a layer of fascia

which forms the wall of the cavity. This fascia consists of layers of fibrous tissue, the fibres of which run in a vertical direction (Fig. 9, e).

At some parts these layers are infiltrated with extravasated blood. Several large veins of the prostatic plexus are seen lying between the layers, and it is important to note that they are not exposed on the inner surface of the fascia, but are separated from the cavity by layers of tissue (Fig. 9, f).

At the lower part of this section the fibrous sheath becomes embedded in striped muscle-fibre, which lies alongside the urethral wall.

This striped muscle passes outwards on the inner surface of the sheath for a short distance and then disappears (Fig. 9, i). These striped muscle-fibres have already been described in the macroscopic examination of the specimen.

At the upper part of the section the fibrous sheath becomes wedged in between the layers of the bladder muscle, a thin layer of non-striped muscle being continued down on its inner surface for a short distance from the circular bladder muscle (Fig. 9, k).

The wall of the cavity between these prolongations of muscle from the bladder wall, and from the constrictor urethræ, is composed of the fibrous sheath. At one part, however, a small nodule of prostatic tissue, the size of a pin's head, was found adhering to the wall, having been left behind at the operation (Fig. 9, l).

On examining this nodule more carefully it is found to be separated from the fibrous sheath by a portion of the non-striped muscle capsule of the prostate (Fig. 10, *b*). The glandular tissue consisted of the usual dilated tubules found in enlarged prostates (Fig. 10, *a*). There were no layers of compressed gland tissue between the nodule and the sheath, such as have been said to surround the enlarged prostate.

Sections were also made of other parts of the wall, and shewed that it consisted of wavy layers of fibrous tissue (Fig. 11, *b*). The prostatic plexus was not, of course, represented in these sections. No further nodules of prostatic tissue were found. In the second specimen, sections of different parts of the wall of the cavity failed to reveal any trace of prostatic tissue, and there were no layers of the muscular capsule of the prostate left behind.

FIG. 10.—SECTION OF NODULE OF PROSTATIC TISSUE LEFT ADHERENT TO SHEATH AFTER PROSTATECTOMY.

a. Nodule of prostatic tissue. *b*. Portion of capsule of prostate. *c c*. Fibrous sheath forming wall of cavity. *d*. Vein of prostatic plexus between layers of sheath. *e*. Infiltration of blood in sheath.

V.— OBSERVATIONS UPON THE OPERATION OF PROSTATECTOMY.

I have endeavoured in the preceding pages to give an account of the changes in the enlarged prostate which render prostatectomy possible. These changes are briefly two in number :—

1. Changes in relation of the prostate to the sheath of pelvic fascia.
2. Changes in the relation of the enlarged prostate to the bladder base.

FIG. 11.—SECTION OF WALL OF CAVITY AFTER PROSTATECTOMY.

a. Cavity from which prostate was removed. *b*. Fibrous tissue forming wall of cavity. *c*. Outer surface of sheath.

Of these two the first is probably the most important to the surgeon.

There are, undoubtedly, cases in which it is found impossible to completely enucleate the prostate. These cases appear to

me to be of two classes. In the one, adenomata are shelled out from within the prostate, and in the other, fragments only of the gland have been torn out.

In the first class the difficulty has arisen in piercing the capsule of the organ, and, as a rule, scissors or other instruments have been used to facilitate this process. But it is from the very fact that the capsule has been pierced that the further difficulty of finding no guiding line for the enucleation has been experienced. A very considerable amount of adenomatous tissue has been removed in this way, and the results of the operation, which has been called an "intracapsular prostatectomy," have been satisfactory.

Whether in these cases there has been some adhesion of the capsule to the sheath, or a lack of freeing of these structures which prevented the surgeon from slipping his finger into the proper plane, or whether the difficulties arose entirely from the fact that the capsule of the gland was pierced at the commencement of the enucleation, I am unable to say, for I can produce no anatomical proof in support of either view.

The second class of cases is a very different one. In this the difficulties commence when the operator first attempts to pierce the bladder floor, and they continue as he endeavours, without any line of guidance, to enucleate a tough, resisting mass, and finally tears away two or more portions of tissue of indiarubber-like consistence. These prostates form members of a group which have been termed "fibrous prostates." I have reason to doubt whether this term should be used in any but a purely clinical sense. I have met with two examples of this form of fibrous prostate. In the first I removed with very great difficulty a slightly enlarged prostate of this tough consistence, and in the second I completed an operation upon a similar case, which had already been commenced. Both these prostates were carcinomatous under the microscope, although in each case special care had been taken to exclude malignant disease. In these cases the prostate was firmly bound down to its sheath.

That the changes in the relation of the enlarged prostate to the bladder base are not absolutely essential for the performance of prostatectomy is shewn by the fact that a certain number of enucleated prostates of the series I examined were wholly extravesical. In such a case, however, the bladder base

must be stretched over the increased mass of the enlarged prostate, and this will form a point of resistance against which the finger works in piercing the bladder floor. But there is no doubt that a prominent submucous nodule of prostate in the bladder is of great assistance to the operator at the commencement of the enucleation.

Further, I have described the structures removed at the operation and those left behind after the operation. I believe that there is sufficient evidence in the foregoing pages to prove that this operation is a complete prostatectomy, that is to say, a removal of the gland and capsule from the sheath. A nodule has been described adhering to the wall of the cavity after removal of the prostate in one case, and, from the examination of enucleated prostates, it has been inferred that, in a few, portions of the capsule or small nodules of prostatic tissue may have been left behind.

The fact that in one or two out of over seventy cases these accidents should have occurred does not, to my mind, vitiate the completeness of the operation. In an operation of this magnitude, carried out as rapidly as possible by manipulations with the finger and not by dissection under the eye, it would be impossible, I believe, to obtain a microscopically perfect result in every case. But it appeared to have been perfect, or almost so, in the majority of cases I examined. The question has been raised whether the line of cleavage passed within the capsule of the gland. I have no hesitation in giving my opinion that, so far as the operation represented by these specimens is concerned, the line of cleavage is not within the capsule but between the capsule and the sheath.

The line along which the enucleation takes place may be shortly stated as follows :—

After scraping through the mucous membrane covering the intravesical projection the finger meets the capsule of the prostate and passes along outside this, stripping the mucous membrane from off it. Keeping always to the capsule, the finger now passes through the lumen of the dilated vesical sphincter and is guided by these structures between the prostatic sheath and the prostatic capsule. The finger can now be swept around one lobe. Continuing the enucleation, some adhesion will be felt in the position of the ejaculatory ducts, and when

this is torn through the finger can be swept round the other lobe. The prostate is now felt adherent along the middle line anteriorly, and this adhesion, which is probably due to the vertical band of Henle's muscle, is also torn through. By raising the gland with the finger the urethra is severed at the junction of the prostatic with the membranous portion, and the prostatic mass is easily projected upwards into the bladder.

Two great dangers have been supposed to militate against the performance of a complete prostatectomy—the danger of hæmorrhage from the prostatic plexus of veins, and of infiltration of urine into the areolar planes of the pelvis. It is therefore necessary to touch very briefly on these two points.

The position of the veins of the prostatic plexus here described differs from that usually accepted, and described in our anatomical text-books. In making sections of the prostate I was at once struck by the position of these veins between the layers of the sheath, and, therefore, in a safe position even should the whole of the prostate and its capsule be removed. Since making these observations I have learned that Dr. Proust, of Paris, had pointed out the importance of this position in relation to perineal prostatectomy in his thesis of 1900.

In none of the large number of specimens which I examined for this investigation had there been any trouble from hæmorrhage. It may therefore be accepted that the fear of the pressing danger of hæmorrhage was founded upon a mistaken conception of the relations of the prostate to the prostatic venous plexus.

Infiltration of urine was supposed to be the necessary sequel to the removal of the prostate should the prostatic urethra be injured. It is now known that the prostatic urethra may be completely removed, and that in such a case the wall of the cavity (here the prostatic sheath) is a sufficient barrier against infiltration of urine into the areolar tissue of the pelvis.

SUMMARY.

1. The prostate is surrounded by a capsule, which is a part of the stroma, and outside this is a sheath formed by the pelvic fascia.

2. These two structures may be separated by dissection, except at certain parts, but the gland cannot be enucleated in the normal subject.

3. The prostatic plexus of veins is in the form of a Y, with a vertical stem passing up the front of the gland and horizontal arms surrounding its base. The veins lie between the layers of the sheath.

4. In enlargement of the prostate two important changes take place: a change in the relation of the organ to its sheath and a change in relation to the bladder floor.

5. The structures removed at the operation of prostatectomy consist of the enlarged prostate and its capsule.

6. The walls of the space left after removal of these structures are formed by the sheath of pelvic fascia, between the layers of which are the prostatic venous plexus and the seminal vesicles.

7. The operation is a complete prostatectomy.